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Surgeon at work

Superior staple formation with powered stapling devices

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The development and improvement of stapling devices has aided in advancing surgical techniques. Moreover, these devices have shortened operative time and improved perioperative safety [1]. Cartridges are manufactured with a variety of different staple heights, which correspond to the thickness of the intended tissue [2]. After the stapler is fired, staples are formed into B-shaped staples. The shape of a staple that is formed by a stapling device is one industry-accepted indicator of device performance; typically a B-shaped staple is considered the most important indication of a secure anastomosis [3–6]. In recent years, powered stapling devices have been developed and are widespread. With the controlled speed of stapling, it is claimed that staple formation became superior, but there is no detailed report concerning these results.

In previous reports, stapled organs were disintegrated by chemical dissolution to evaluate the shape of the staples [5]. Therefore, the arrangement of the staples collapsed. This makes it impossible to evaluate the status of the staple as a whole. To evaluate the characteristics of the stapler, it is very useful for all the staples to be observed in the original sequence. In this study, we stapled the intestine with a manual and a powered stapler; the shapes of the formed staples were compared between these staplers to verify the superiority of the powered stapling devices. Additionally, we compared these stapler with a method of gradually squeezing the handle multiple times or a method of stapling immediately after the jaws were closed.

Material and methods

Fresh porcine small bowel was used for all experiments. The specimens were obtained from animals that had been sacrificed for use in approved nongastrointestinal research studies. The specimens were used within 24 hours after sacrifice. Each segment of the intestinal tract was 20 cm in length. The front and rear walls of the small intestine segments were stapled in the longitudinal direction using a linear surgical stapler. To match the thickness of the human small intestine, the 2 pieces of intestine were overlapped in the experiments. The stapling devices used were ECHELON FLEX with Ethicon Echelon Stapler Reloads White (ECR60 W, Ethicon, Sukagawa, Japan). To observe the staples in the original sequence, we performed the stapling procedure shown in Fig. 1. First, we wrapped a plastic bag on the cartridge side of the stapler (a), and then we stapled the intestine (b). Each device was clamped on the tissue for 1 minute. The experiments were divided into 4 groups based on the stapling methods. In group A, stapling was started as soon as the jaws were closed so that there was no compression. In groups B, C, and D the jaws were closed and held for 1 minute before firing (precompression). In group B, stapling was performed in the usual way, so that it was completed manually, squeezing the handle 3 times. In group C, powered stapling was performed. In group D, stapling was performed by gradually grasping the handle multiple times. Three intestines in each group were completed. After stapling, the intestine with a plastic bag was put in the sodium hydroxide to dissolve the intestine (c, d).

Observation was carried out in a state in which all of the staples were attached to a plastic bag. We divided the specimens into +/– by the malformation direction of the

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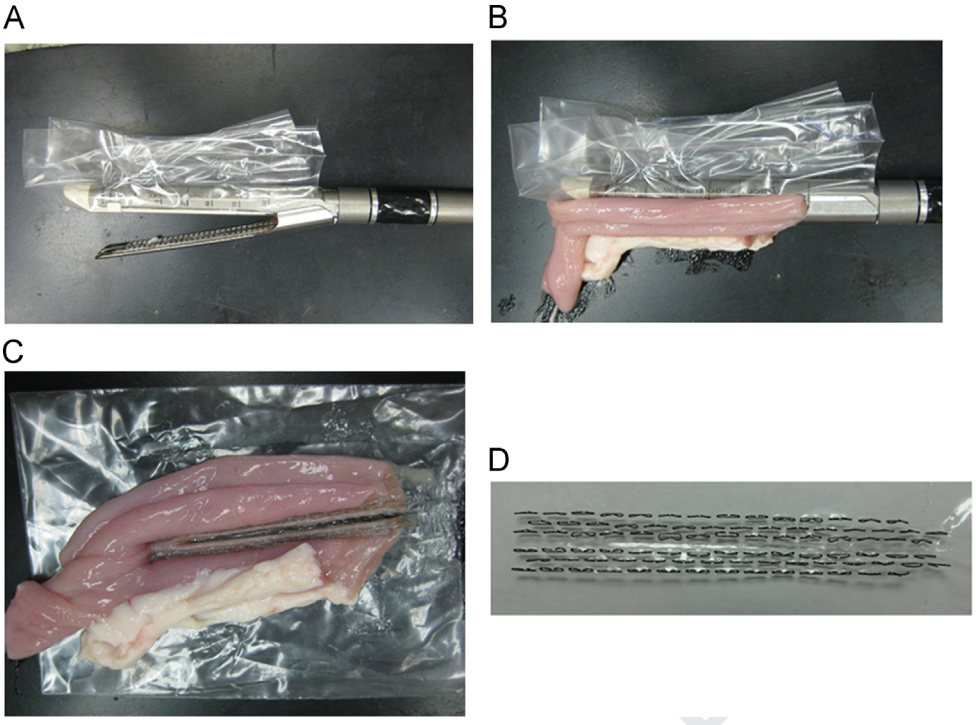

Fig. 1. Stapling procedure. (A) A plastic bag is wrapped on the cartridge side of the stapler. (B) After grasping the small intestine. (C) Stapled small intestine with a plastic bag. (D) All 88 staples attached to a plastic bag.

hook portion. We gave a negative score when the hook portion was malformed to the knife side and a positive score when the hook portion was malformed to the outside. The degree of malformation was categorized into 4 scores: 0, well-formed staples; 1, the degree of malformation is so small that the hook portion is in contact with the linear portion; 2, the distance of the hook portion from the linear portion is less than twice the diameter of the staple; and 3, the degree of malformation is larger than score 2

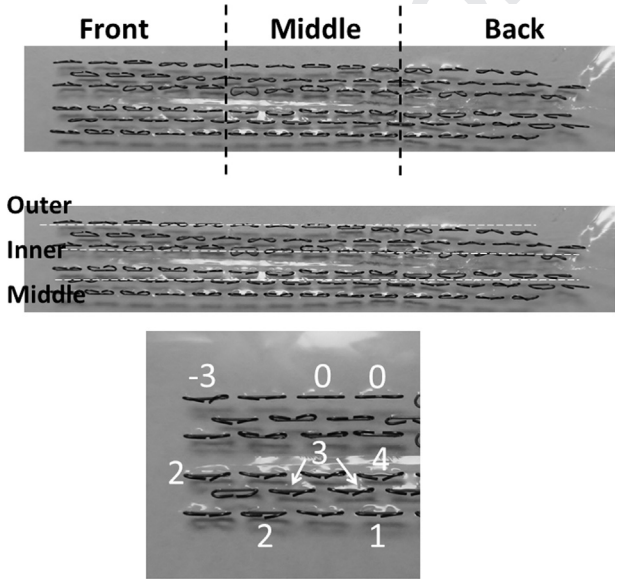

Fig. 2. Columns and location and example of the score.

The degree of malformation was evaluated by the total of the 2 hooks. The number of malformed staples, strongly malformed staples, and staples malformed to the knife side and the absolute value of the malformation degree were compared for each group. Furthermore, the 88 staples were divided by columns (inner, middle, outer) and location (front, middle, back), and they were compared with each other (Fig. 2).

In group D, the staples in the front row (6 staples) were excluded from the measurement because the staples are not fully formed from the structure of the stapler. The number of staples in the outer row was one less than other rows. Based on these features, the number of malformed staples, strongly malformed staples, and staples malformed to the knife side were expressed as percentages. The absolute value of the malformed degree was expressed as the average per staple.

Statistical analysis

Discrete variables were analyzed by the Mann-Whitney test and significance was indicated at $P < .05$.

Results

In all experiments, 88 staples could be observed while attached to the plastic bag. The number of malformed staples and malformations ≥ 2 and the absolute value of the degree of malformation were significantly lower in group C compared with groups A, B, and D (Table 1). Regardless of